CHEMICAL ANALYSIS OF ADSORBATES FROM BREATHING CANISTERS FROM APOLLO 10 SPACECRAFT

Final Report on Contract NAS-98872
Job Order No. 5

To

National Aeronautics And Space Administration
Manned Spacecraft Center
Houston, Texas

Report No. 3762

July 1969

Aerojet-General Corporation
Analytical Chemistry Laboratories

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CONTRACT FULFILLMENT STATEMENT

This final report is submitted to the National Aeronautics and Space Administration Manned Spacecraft Center in completion of Job Order No. 5 on Contract NAS 9-8872.

APPROVED:

M. L. Moberg

M. L. Moberg, Manager
Analytical Chemistry Laboratories
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FOREWORD

This report completes the requirements of Job Order No. 5 on NAS 9-8872 and comprises analytical data for the charcoal and lithium hydroxide adsorbents from canisters used in the Apollo 10 Spacecraft and a LEM-4 charcoal sample. The analytical work was performed at the Aerojet-General Corporation's Analytical Chemistry Laboratories by the same technical staff that provided the analytical services on the previous job orders. The charcoal desorption data were generated by using chromatographic and mass spectrometric methods similar to those established for Job Orders 1 thru 4. Mr. C. L. Deuel acted as project engineer and chromatographer, assisted by E. A. Tombleson as chromatographer, and D. L. Quick and N. W. Hultgren as mass spectrometrists. Chemical methods were used by Y. Kadota to obtain the lithium hydroxide data. The contract was technically managed by M. L. Moberg.

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I. INTRODUCTION AND SUMMARY

The analytical information presented in this report was obtained from treatment of the Apollo 10 breathing canisters. Procedures for sample treatment and analyses are similar to those used in earlier Apollo reports, i.e., Report No. 3695 and 3745, and reflect the most current methods for trace analysis used by Aerojet's Analytical Laboratories. These approaches included wet chemical analysis of the lithium hydroxide packing and gas chromatographic and mass spectrometric analysis of the charcoal adsorbates.

With the experience developed in trace analyses from Apollo breathing canisters and continuous improvement in sample processing and trace component identification, the confidence level of the presented data is virtually 100% on all major compounds and an estimated 90% on the very minor compounds. In forthcoming studies, a third chromatographic column will be used with MS qualification for better resolution of the moderate number of low boiling constituents found in some of the samples.

The comments given in the following paragraphs, concerning the charcoal desorbed materials, are offered to substantiate and elaborate the reported data.

II. TECHNICAL DISCUSSION

The compounds reported as C_xF_y were identified and verified by mass spectrometry. These are presented as semi-quantitative data because chromatographic splitting of these from the freons could not be achieved for correlation with standard gas mixtures. However, mass spectrometry did provide relative concentrations of these materials with other chromatographically calibrated sample components. Another indication of type and amount of components in the early chromatographic signal is the variation in ratio of electron capture (EC) to flame ionization (FID) signal between samples. This is reproducible in replicate measurements from the same charcoal. If only ethylene or propylene were present, no EC response would be expected. Conversely, if only low boiling C_xF_y materials were present, essentially no FID response would be expected. For many of the samples strong EC and FID signals were observed. These compounds were reported previously but not at significant levels as in the Apollo 10 samples.

Isoprene was positively identified by mass spectrometry at the appropriate retention time on the Carbowax column. The retention time of Freon 113 is quite similar however, and when large amounts of this compound (F-113) are present, considerable masking on both GC columns and mass spectrometry occurs.

The increase in quantity of trimethyl fluorosilane (previously indicated as silicone 1) over data reported earlier is significant and reconfirmed. Possibly some electronic component or pressure seal was recently installed in the Apollo 10 module before complete cure of the component had been realized. Another sample component that may have been present at low levels in earlier analysis is methyl alcohol. If the concentration of methyl alcohol is low, i.e., less than 0.01 $\mu g/M^3$, the chromatographic signal is diffuse and merges with methylene chloride on the Carbowax column. However, if the concentration increases, a moderately well shaped GC signal merges and both the alcohol and halocarbon signals resolve. Cryogenic concentration processes enhance this separation. The chromatographic signal profiles for the alcohols are poor on the n-butyl phthalate column.

Acetonitrile was positively confirmed with mass spectrometry and gas chromatography. The absence of this material in earlier charcoal adsorbates was of concern to the laboratory. However, a review of selected previous chromatograms showed no evidence of acetonitrile in contrast to the current studies.

Diisopropyl amine and methoxy acetic acid are suggested as sample components by mass spectrometry. These components were occasionally observed in previous samples and reported as unknowns. Retention volumes of known materials are similar and support mass spectrometric assignments. Other components such as sulfur dioxide and dimethyl sulfide were identified by mass spectrometry.

Finally, each sample was carefully checked for dichloroacetylene. Neither chromatographic or spectrometric evidence was found for its presence and therefore it is concluded that DCA is not present in any of the received samples.

TABLE 1

ANALYSIS OF CONTAMINANTS ON CHARCOAL ADSORBED FROM APOLLO 10 SPACECRAFT BREATHING CANISTERS

(Products Vacuum Desorbed and Trapped at LN_2 Temperature, μg/g charcoal)

Compound Identified	Canister Number 29-424	29-430	29-433	39-452
Freon 11	44.6	18.9	19.3	4.87
Freons 12 & 22	85.7	19.0	91.3	12.1
Freon 113	155.	74.9	254.	81.4
Ethylene	12.8	12.5	18.8	162.
Propylene	380.	160.	218.	174.
Trimethyl butane	-	1.21	-	0.12
Isoprene	0.063	0.021	0.18	0.37
n-Pentane	-	-	-	-
Pentene-1	10.8	5.35	14.7	5.22
Isopentane	1.91	1.43	1.13	1.04
Cyclopentene	0.77	0.21	-	0.49
Methyl cyclopentane	-	0.32	0.41	0.28
n-Hexane	-	0.21	0.23	-
Hexene-2	0.77	0.07	0.38	0.035
Cyclohexane	1.45	1.44	0.98	0.56
Methyl cyclohexane	0.088	0.98	0.21	0.69
Benzene	0.66	1.47	1.31	0.37
Toluene	0.21	0.48	1.73	0.50
m-Xylene	-	0.012	0.0019	-
o-Xylene	-	-	0.0018	-
Ethyl benzene	0.0005	0.012	0.0029	-
Styrene	-	0.012	0.016	0.023
C_9 Aromatics	-	0.0006	0.0026	0.019
C_{10} Aromatics	0.0005	0.0012	0.0010	-
n-Heptane	0.47	0.52	0.48	0.42
Acetone	66.2	29.4	22.5	24.0
Methyl ethyl ketone	0.043	0.16	-	0.035
Methyl isobutyl ketone	-	-	-	0.007
Methyl acetate	0.15	0.031	0.10	0.023
Ethyl acetate	2.27	1.54	1.98	1.60
Butyl acetate	-	-	-	-
Methyl alcohol	0.68	0.35	0.48	0.15
Ethyl alcohol	0.76	1.12	0.81	0.96
Propyl alcohol	-	-	-	-
Isopropyl alcohol	0.52	0.70	2.53	0.37
Butyl alcohol	0.0055	0.010	0.0033	0.023
Isobutyl alcohol	-	0.0047	-	-
sec-Butyl alcohol	0.011	0.0062	-	-
tert-Butyl alcohol	-	-	-	-

TABLE 1 (Cont.)

(Products Vacuum Desorbed and Trapped at LN_2 Temperature, μg/g charcoal)

Compound Identified	Canister Number 29-424	29-430	29-433	39-452
Methylene chloride	3.29	1.87	3.13	1.39
Methyl chloroform	0.18	0.12	0.096	0.20
Vinylidene chloride	0.29	0.005	0.34	0.28
Trichloroethylene	1.77	0.054	1.67	0.32
Tetrachloroethylene	0.13	0.10	0.19	0.046
Chlorobenzene	-	-	-	-
Dichlorobenzene	-	-	-	-
Tetrachloroethane	-	0.0015	-	-
Acetaldehyde	0.060	1.25	1.88	0.24
Acetonitrile	0.33	0.18	0.098	0.090
Diisopropyl amine	0.0005	0.0012	0.0033	-
Furan	0.16	0.16	0.090	0.19
Dioxane	0.055	0.062	0.16	0.11
Dimethyl sulfide	-	0.021	0.024	-
Sulfur dioxide	-	-	-	0.002
Methoxy acetic acid	0.0014	-	0.0013	0.009
Water (mg/g charcoal)	19.4	16.8	18.5	16.4
$(CH_3)_3SiF$ (1)	-	-	7.26	16.0
Silicones				
V_R 120	0.19	2.11	0.13	0.68
V_R 350	-	0.062	0.006	-
V_R 550	0.0033	0.10	0.0013	-
V_R 720	0.0016	-	0.0016	-
V_R 850	0.016	0.0006	0.0065	-
V_R 920	0.014	0.0065	0.016	-
Semi-Quantitative MS Analyses				
V_R 54**	106.	143.	97.5	64.6
V_R 75*	32.3	1.75	3.63	1.56
Unknowns				
V_R 1065	0.0005	0.0022	0.0006	0.009
V_R 1100	-	-	0.0010	0.005
V_R 1130	-	-	0.0006	-

*CO_2, FClC = CF_2; C_3F_8, CF_4, C_3F_6, C_2F_4, C_2 & C_3 hydrocarbons

**CF_2 = CCl_2, Freon 21, C_4 - C_6 hydrocarbons

(1) Includes some C_xF_y compounds, C_2 & C_3 hydrocarbons

TABLE 1 (Cont.)

(Products Vacuum Desorbed and Trapped at LN_2 Temperature, μg/g charcoal)

Compound Identified	Canister Number 39-454	39-457	39-459	39-461
Freon 11	14.7	6.79	1.24	1.71
Freons 12 & 22	9.85	2.71	0.69	3.64
Freon 113	32.4	17.6	4.0	14.3
Ethylene	9.02	2.23	1.66	16.4
Propylene	210.	64.1	27.9	114.
Trimethyl butane	-	-	-	-
Isoprene	0.003	0.91	-	1.12
n-Pentane	-	-	-	-
Pentene-1	3.21	0.57	0.080	0.037
Isopentane	1.80	0.11	0.10	-
Cyclopentene	0.25	0.25	0.050	1.35
Methyl cyclopentane	0.11	0.080	-	0.011
n-Hexane	0.04	0.11	0.050	0.37
Hexene-2	-	-	-	-
Cyclohexane	0.78	0.41	0.037	0.64
Methyl cyclohexane	0.055	0.066	-	0.062
Benzene	0.52	0.57	0.012	0.60
Toluene	0.19	0.071	0.0041	0.071
m-Xylene	0.0016	0.0017	0.0006	0.0006
o-Xylene	0.0016	0.0007	0.0014	0.0003
Ethyl benzene	0.0042	0.0017	0.0014	0.0008
Styrene	0.0022	0.0010	0.0003	0.0009
C_9 Aromatics	0.0013	0.0020	-	0.0003
C_{10} Aromatics	0.0010	0.0017	-	-
n-Heptane	0.24	-	-	-
Acetone	22.1	29.3	1.70	27.5
Methyl ethyl ketone	0.0067	0.010	0.0009	0.0071
Methyl isobutyl ketone	-	0.0025	-	-
Methyl acetate	0.0008	0.0067	-	0.0016
Ethyl acetate	0.75	0.42	0.012	0.19
Butyl acetate	-	-	-	-
Methyl alcohol	0.16	0.061	0.11	0.67
Ethyl alcohol	1.10	0.74	1.34	1.41
Propyl alcohol	-	-	0.020	-
Isopropyl alcohol	0.96	0.99	0.94	0.71
Butyl alcohol	0.0024	-	0.0014	-
Isobutyl alcohol	0.0024	0.0050	0.0007	0.0016
sec-Butyl alcohol	0.013	0.0025	0.011	0.0004
tert-Butyl alcohol	-	-	-	-

TABLE 1 (Cont.)

(Products Vacuum Desorbed and Trapped at LN_2 Temperature, μg/g charcoal)

Compound Identified	Canister Number 39-454	39-457	39-459	39-461
Methylene chloride	1.69	0.78	1.91	3.54
Methyl chloroform	0.25	0.047	0.007	0.059
Vinylidene chloride	0.002	0.0013	0.0004	0.0016
Trichloroethylene	0.24	0.0077	< 0.0001	0.044
Tetrachloroethylene	0.013	0.017	0.0014	0.011
Chlorobenzene	0.0032	-	-	-
Dichlorobenzene	-	-	< 0.0001	< 0.0001
Tetrachloroethane	-	-	-	-
Acetaldehyde	0.54	0.38	-	-
Acetonitrile	0.15	0.065	0.0009	0.22
Diisopropyl amine	0.0006	0.0040	0.0026	0.0028
Furan	0.11	0.12	0.0078	0.13
Dioxane	0.036	0.018	0.017	0.045
Dimethyl sulfide	0.013	0.009	-	0.0003
Sulfur dioxide	0.001	-	-	-
Methoxy acetic acid	0.0026	0.0017	0.0003	0.0009
Water (mg/g charcoal)	16.7	16.5	15.4	21.0
$(CH_3)_3SiF$ (1)	2.94	1.97	0.070	0.20
Silicones				
V_R 120	0.018	0.0040	0.0006	-
V_R 350	-	-	-	-
V_R 550	0.0032	-	-	0.0030
V_R 720	-	-	0.0014	-
V_R 850	-	0.0010	0.0009	0.0003
V_R 920	0.0026	0.0013	0.0001	0.0009
" 995	0.0016	-	0.0003	-
Semi-Quantitative MS Analyses				
V_R 54*	29.4	7.98	0.55	21.5
V_R 75**	0.39	0.22	0.029	0.20
Unknowns				
V_R 1065	0.0016	0.0013	-	-
V_R 1100	0.0013	0.0007	0.0006	-
V_R 1125	0.0003	0.0010	-	-
V_R 1150	0.0006	-	-	-

*CO_2, $FClC = CF_2$; C_3F_8, CF_4, C_3F_6, C_2F_4, C_2 & C_3 hydrocarbons

**$CF_2 = CCl_2$, Freon 21, $C_4 - C_6$ hydrocarbons

(1) Includes some C_xF_y compounds, C_2 & C_3 hydrocarbons

TABLE 1 (Cont.)

(Products Vacuum Desorbed and Trapped at LN_2 Temperature, μg/g charcoal)

Compound Identified	Canister Number 39-464	39-473	39-474	39-478
Freon 11	12.0	13.6	10.1	22.5
Freons 12 & 22	1.21	7.83	2.59	6.27
Freon 113	11.6	51.4	10.8	41.0
Ethylene	1.61	6.70	3.74	6.43
Propylene	34.8	157.	60.5	228.
Trimethyl butane	-	-	-	-
Isoprene	0.080	0.19	1.35	0.68
n-Pentane	-	-	-	-
Pentene-1	0.058	3.01	1.51	0.48
Isopentane	-	0.90	0.56	0.32
Cyclopentene	0.13	0.23	0.34	0.45
Methyl cyclopentane	-	0.22	0.18	-
n-Hexane	0.029	0.067	0.22	0.16
Hexene-2	-	0.067	-	-
Cyclohexane	0.029	0.93	0.49	1.69
Methyl cyclohexane	0.0039	0.10	0.082	0.028
Benzene	0.098	0.39	0.64	0.43
Toluene	0.025	0.097	0.21	0.010
m-Xylene	0.0008	-	0.0016	0.0065
o-Xylene	-	-	-	-
Ethyl benzene	0.0011	0.0009	0.0013	0.0020
Styrene	0.0011	0.0009	-	-
C_9 Aromatics	0.0003	-	-	0.0014
C_{10} Aromatics	0.0006	-	0.0016	0.0006
n-Heptane	-	0.080	-	-
Acetone	1.78	18.0	8.26	72.9
Methyl ethyl ketone	0.0008	0.0009	0.0039	0.092
Methyl isobutyl ketone	-	-	0.0005	-
Methyl acetate	-	0.029	-	0.034
Ethyl acetate	0.018	0.86	0.38	0.99
Butyl acetate	-	-	-	-
Methyl alcohol	0.0059	0.51	0.061	0.099
Ethyl alcohol	0.19	1.02	0.35	1.07
Propyl alcohol	-	-	-	-
Isopropyl alcohol	0.14	0.39	0.24	0.36
Butyl alcohol	-	0.0015	0.0016	-
Isobutyl alcohol	0.0007	0.0022	0.0016	0.0085
sec-Butyl alcohol	0.0049	0.0015	0.0008	-
tert-Butyl alcohol	-	-	-	-

TABLE 1 (Cont.)

(Products Vacuum Desorbed and Trapped at LN_2 Temperature, μg/g charcoal)

Compound Identified	Canister Number 39-464	39-473	39-474	39-478
Methylene chloride	0.79	2.08	1.03	6.30
Methyl chloroform	0.013	0.074	0.013	0.11
Vinylidene chloride	0.016	-	0.007	-
Trichloroethylene	0.017	0.19	0.068	0.20
Tetrachloroethylene	0.011	0.038	0.0032	0.042
Chlorobenzene	-	-	-	0.0007
Dichlorobenzene	0.0007	-	-	0.0003
Tetrachloroethane	-	-	-	-
Acetaldehyde	0.0042	1.34	0.13	0.80
Acetonitrile	0.0087	0.22	0.020	0.33
Diisopropyl amine	0.0014	0.0003	0.0010	0.019
Furan	0.037	0.20	0.065	0.20
Dioxane	0.012	0.044	0.018	0.042
Dimethyl sulfide	-	0.014	0.011	-
Sulfur dioxide	-	-	-	-
Methoxy acetic acid	0.0006	0.0006	0.0013	0.0008
Dimethyl disulfide	-	-	-	0.0014
Water (mg/g charcoal)	15.5	16.3	17.2	17.3
$(CH_3)_3SiF$ (1)	0.021	5.45	3.89	0.56
Silicones				
V_R 120	0.0011	0.028	0.0026	-
V_R 350	-	-	-	-
V_R 550	-	0.0017	-	0.0040
V_R 720	0.0028	-	-	-
V_R 850	0.0003	0.0001	0.0005	0.0020
V_R 920	-	0.0003	0.0003	0.0031
Semi-Quantitative MS Analyses				
V_R 54**	4.59	28.4	23.4	60.9
V_R 75	2.33	2.83	0.19	0.86
Unknowns				
V_R 1065	-	-	0.0003	0.0003
V_R 1125	-	0.0001	-	0.0003
V_R 1150	-	0.0003	-	-

*CO_2, $FC1C = CF_2$; C_3F_8, CF_4, C_3F_6, C_2F_4, C_2 & C_3 hydrocarbons

**$CF_2 = CCl_2$, Freon 21, $C_4 - C_6$ hydrocarbons

(1) Includes some C_xF_y compounds, C_2 & C_3 hydrocarbons

TABLE 1 (Cont.)

(Products Vacuum Desorbed and Trapped at LN_2 Temperature, $\mu g/g$ charcoal)

Compound Identified	Canister Number 39-479	39-484	39-489	39-522
Freon 11	3.10	19.9	19.1	0.10
Freons 12 & 22	4.47	13.1	7.09	0.48
Freon 113	31.0	52.2	70.8	25.8
Ethylene	3.32	5.83	13.6	-
Propylene	375.	186.	218.	66.6
Trimethyl butane	-	-	-	-
Isoprene	0.037	0.22	0.066	0.026
n-Pentane	-	-	..	-
Pentene-1	1.36	4.90	4.60	0.77
Isopentane	0.66	0.39	0.34	0.44
Cyclopentene	0.55	0.70	0.41	0.022
Methyl cyclopentane	0.16	0.19	0.24	0.067
n-Hexane	0.19	0.19	0.10	-
Hexene-2	-	0.08	-	-
Cyclohexane	-	0.90	1.76	0.022
Methyl cyclohexane	0.029	0.077	0.68	0.039
Benzene	0.75	0.86	0.93	0.50
Toluene	0.051	0.39	0.41	0.060
m-Xylene	0.022	-	0.0088	0.0041
o-Xylene	0.0009	-	0.031	0.0006
Ethyl benzene	0.0034	0.0030	0.0044	0.0030
Styrene	0.0014	0.0037	0.0009	0.0010
C_9 Aromatics	0.0009	0.0010	-	0.0020
C_{10} Aromatics	0.0034	0.0005	0.0039	0.0016
n-Heptane	0.013	0.39	0.75	-
Acetone	33.2	47.4	26.5	6.24
Methyl ethyl ketone	0.0052	0.020	0.072	0.023
Methyl isobutyl ketone	0.0022	-	0.0066	0.0015
Methyl acetate	0.0014	0.013	0.0044	-
Ethyl acetate	0.38	1.76	1.71	0.065
Butyl acetate	-	-	-	0.0074
Methyl alcohol	0.55	0.35	0.68	0.51
Ethyl alcohol	0.49	1.08	0.17	0.29
Propyl alcohol	-	-	-	-
Isopropyl alcohol	0.52	1.02	0.32	0.26
Butyl alcohol	0.0007	0.0017	-	-
Isobutyl alcohol	0.0086	0.0067	-	0.0041
sec-Butyl alcohol	0.0014	-	-	-
tert-Butyl alcohol	-	-	-	-

TABLE 1 (Cont.)

(Products Vacuum Desorbed and Trapped at LN_2 Temperature, μg/g charcoal)

Compound Identified	Canister Number 39-479	39-484	39-489	39-522
Methylene chloride	1.58	1.35	0.87	0.092
Methyl chloroform	0.10	0.11	0.12	0.12
Vinylidene chloride	0.012	-	-	0.14
Trichloroethylene	0.11	0.39	0.75	0.033
Tetrachloroethylene	0.043	0.067	0.044	0.015
Chlorobenzene	-	-	0.0066	-
Dichlorobenzene	0.0007	0.0012	-	0.0003
Tetrachloroethane	-	-	-	-
Acetaldehyde	0.78	-	0.24	-
Acetonitrile	0.24	0.15	0.039	0.013
Diisopropyl amine	0.064	0.0017	-	-
Furan	0.18	0.16	0.33	0.030
Dioxane	0.033	0.051	0.033	0.074
Dimethyl sulfide	0.009	0.006	0.008	-
Sulfur dioxide	-	-	-	0.003
Methoxy acetic acid	0.0006	0.013	0.022	0.0010
Water (mg/g charcoal)	17.2	17.7	15.9	15.6
$(CH_3)_3SiF$ (1)	0.49	8.96	13.2	1.68
Silicones				
V_R 120	0.22	0.37	0.088	0.034
V_R 350	0.12	0.16	-	-
V_R 550	-	0.0040	-	-
V_R 720	-	0.0013	-	-
V_R 850	0.0009	0.0010	-	0.0003
V_R 920	0.0046	0.0013	-	0.0010
V_R 995		0.022		
Semi-Quantitative MS Analyses				
V_R 54*	17.3	81.6	123.6	38.4
V_R 75**	1.78	1.18	2.28	0.84
Unknowns				
V_R 1065	0.0009	0.0007	0.0004	0.0010
V_R 1100	0.0006	0.0003	-	-
V_R 1125	-	0.0003	0.0088	0.0003

*CO_2, FClC = CF_2; C_3F_8, CF_4, C_3F_6, C_2F_4, C_2 & C_3 hydrocarbons

**$CF_2 = CCl_2$, Freon 21, C_4 - C_6 hydrocarbons

(1) Includes some C_xF_y compounds, C_2 & C_3 hydrocarbons

TABLE 1 (Cont.)

(Products Vacuum Desorbed and Trapped at LN_2 Temperature, μg/g charcoal)

Compound Identified	Canister Number 39-523	39-527	39-530	39-531
Freon 11	71.0	45.6	10.9	2.23
Freons 12 & 22	-	53.4	3.37	1.11
Freon 113	353.	242.	36.1	11.6
Ethylene	11.8	9.77	5.56	3.19
Propylene	257.	266.	91.2	90.6
Trimethyl butane	-	-	-	-
Isoprene	1.83	1.74	2.49	0.43
n-Pentane	1.02	-	-	-
Pentene-1	10.1	8.8	2.0	0.15
Isopentane	80.2	1.95	0.37	0.096
Cyclopentene	0.30	-	0.11	-
Methyl cyclopentane	0.37	0.43	0.24	0.029
n-Hexane	0.20	-	0.15	0.30
Hexene-2	0.10	0.39	0.17	-
Cyclohexane	2.27	1.11	0.28	0.15
Methyl cyclohexane	0.12	0.20	0.17	0.016
Benzene	1.54	1.62	2.29	0.16
Toluene	0.52	0.73	0.81	0.0068
m-Xylene	0.012	0.0020	0.024	0.0028
o-Xylene	0.0012	0.0020	-	-
Ethyl benzene	-	0.0034	0.019	0.0008
Styrene	0.043	-	0.005	0.0011
C_9 Aromatics	0.0029	0.0007	0.014	0.0028
C_{10} Aromatics	0.0029	0.0003	0.005	0.0022
n-Heptane	0.36	0.31	0.36	-
Acetone	62.4	48.5	32.6	18.6
Methyl ethyl ketone	0.12	-	0.039	0.0030
Methyl isobutyl ketone	-	-	-	0.0043
Methyl acetate	0.059	0.068	0.024	-
Ethyl acetate	2.46	2.47	1.69	0.20
Butyl acetate	0.044	-	0.006	0.031
Methyl alcohol	0.61	0.31	-	0.49
Ethyl alcohol	2.59	1.25	1.01	0.33
Propyl alcohol	-	-	-	-
Isopropyl alcohol	3.40	3.34	1.15	0.13
Butyl alcohol	0.0022	0.0034	-	-
Isobutyl alcohol	0.0095	0.0017	0.006	0.0035
sec-Butyl alcohol	0.0073	0.0068	0.085	0.0099
tert-Butyl alcohol	-	-	-	-

TABLE 1 (Cont.)

(Products Vacuum Desorbed and Trapped at LN_2 Temperature, μg/g charcoal)

Compound Identified	Canister Number 39-523	39-527	39-530	39-531
Methylene chloride	2.93	2.35	1.02	0.50
Methyl chloroform	0.31	0.057	0.14	0.044
Vinylidene chloride	0.20	-	-	0.12
Trichloroethylene	0.75	0.82	0.24	0.014
Tetrachloroethylene	0.12	0.082	0.0024	0.045
Chlorobenzene	-	-	-	-
Dichlorobenzene	-	-	-	0.0003
Tetrachloroethane	-	-	-	-
Acetaldehyde	-	0.065	0.058	0.096
Acetonitrile	0.25	0.18	0.029	0.079
Diisopropyl amine	0.0059	0.0007	0.007	0.0073
Furan	0.17	0.18	0.20	0.096
Dioxane	0.050	0.047	0.11	0.0094
Dimethyl sulfide	0.054	0.027	-	-
Sulfur dioxide	-	-	-	0.0022
Methoxy acetic acid	0.0015		0.014	
Water (mg/g charcoal)	21.1	17.7	16.5	16.2
$(CH_3)_3SiF$[1]	16.8	21.3	8.55	0.12
Silicones				
V_R 120	0.11	0.22	0.053	-
V_R 350	0.63	0.047	0.052	-
V_R 550	0.0059	0.0027	-	-
V_R 720	-	-	-	-
V_R 850	0.0009	0.014	-	0.0003
V_R 920	0.035	0.0082	0.005	0.0006
Semi-Quantitative MS Analyses				
V_R 54*	97.6	47.1	79.6	30.9
V_R 75**	7.3	0.63	0.21	0.12
Unknowns				
V_R 1065	0.0006	-	0.002	0.0003
V_R 1100	0.0009	0.0003	0.010	0.0003
V_R 1125	0.0006	0.0007	0.005	0.0003

*CO_2, $FC1C = CF_2$; C_3F_8, CF_4, C_3F_6, C_2F_4, C_2 & C_3 hydrocarbons

**$CF_2 = CCl_2$, Freon 21, $C_4 - C_6$ hydrocarbons

(1) Includes some C_xF_y compounds, C_2 & C_3 hydrocarbons

TABLE 1 (Cont.)

(Products Vacuum Desorbed and Trapped at LN_2 Temperature, $\mu g/g$ charcoal)

Compound Identified	Canister Number LEM 4
Freon 11	0.74
Freons 12 & 22	2.58
Freon 113	5.8
Ethylene	1.99
Propylene	11.9
Trimethyl butane	-
Isoprene	-
n-Pentane	0.60
Pentene-1	0.12
Isopentane	0.60
Cyclopentene	0.50
Methyl cyclopentane	0.13
n-Hexane	0.14
Hexene-2	0.060
Cyclohexane	0.020
Methyl cyclohexane	0.023
Benzene	0.68
Toluene	0.72
m-Xylene	0.017
o-Xylene	-
Ethyl benzene	0.0003
Styrene	0.0018
C_9 Aromatics	0.0081
C_{10} Aromatics	-
n-Heptane	0.040
Acetone	0.19
Methyl ethyl ketone	-
Methyl isobutyl ketone	0.0001
Methyl acetate	-
Ethyl acetate	0.048
Butyl acetate	0.0018
Methyl alcohol	-
Ethyl alcohol	0.11
Propyl alcohol	-
Isopropyl alcohol	0.12
Butyl alcohol	0.011
Isobutyl alcohol	0.018
sec-Butyl alcohol	-
tert-Butyl alcohol	-

TABLE 1 (Cont.)

(Products Vacuum Desorbed and Trapped at LN_2 Temperature, μg/g charcoal)

Compound Identified	Canister Number LEM 4
Methylene chloride	0.35
Methyl chloroform	< 0.0001
Vinylidene chloride	-
Trichloroethylene	0.0035
Tetrachloroethylene	0.023
Chlorobenzene	-
Dichlorobenzene	< 0.0001
Tetrachloroethane	< 0.0001
Acetaldehyde	0.014
Acetonitrile	-
Diisopropyl amine	-
Tetrahydrofuran	0.0085
Furan	0.044
Dioxane	0.013
Dimethyl sulfide	-
Sulfur dioxide	-
Methoxy acetic acid	-
Water (mg/g charcoal)	15.4
$(CH_3)_3SiF$	0.38
Silicones	
V_R 120	0.0071
V_R 350	-
V_R 550	0.0011
V_R 720	-
V_R 850	-
V_R 920	-
Semi-Quantitative MS Analyses	
V_R 54*	1.45
V_R 75**	0.36
Unknowns	
V_R 1125	0.0002
V_R 1150	0.0002
V_R 1250 (electron capture)	< 0.0001

*CO_2, FClC = CF_2; C_3F_8, CF_4, C_3F_6, C_2F_4, C_2 & C_3 hydrocarbons

**CF_2 = CCl_2, Freon 21, C_4 - C_6 hydrocarbons

(1) Includes some C_xF_y compounds, C_2 & C_3 hydrocarbons

TABLE 2

CHEMICAL ANALYSIS OF LITHIUM HYDROXIDE

Sample No.	By-pass Valve No.	Wt-%			µg/g of LiOH	
		LiOH	Li_2CO_3	Total	NO_2*	SO_2**
29-424	2	30.6	61.8	92.4	4	19
29-430	8	32.0	58.4	90.4	2	< 2
29-433	1	41.2	52.0	93.2	2	29
39-452	6	21.5	73.5	95.0	< 2	38
39-454	9	40.8	52.4	93.2	< 2	< 2
39-457	13	35.0	65.3	100.3	12	21
39-459	19	97.6	2.0	99.6	12	38
39-461	17	52.5	41.7	94.1	5	2
39-464	18	62.3	35.7	98.0	2	< 2
39-473	5	38.3	57.1	95.4	5	27
39-474	16	38.4	54.4	92.8	< 2	37
39-478	11	32.7	59.2	91.9	< 2	9
39-479	12	36.3	56.8	93.1	< 2	42
39-484	10	17.7	76.5	94.2	< 2	40
39-489	7	15.6	78.8	94.4	2	27
39-522	20	97.7	1.7	99.4	< 2	45
39-523	3	26.6	68.9	95.5	9	48
39-527	4	24.6	69.0	93.6	2	29
39-530	15	20.8	74.0	94.8	2	43
39-531	14	41.8	50.1	91.9	2	36

* Oxides of nitrogen (NO_x) calculated as NO_2.

** Oxides of sulfur (SO_x) calculated as SO_2. H_2S would also be included if present.

TABLE 3

APOLLO 10 ADSORBENT CANISTERS

Canister Number	By-pass Valve No.	Total Weight of Canister, g	Net Weight of Charcoal, g
29-424	2	3024.9	104.71
29-430	8	3025.8	102.34
29-433	1	2854.5	103.46
39-452	6	3060.8	102.67
39-454	9	2905.4	102.62
39-457	13	2962.8	102.44
39-459	19	2289.5	101.97
39-461	17	2767.8	106.20
39-464	18	2577.6	101.98
39-473	5	2948.0	103.90
39-474	16	2930.5	104.42
39-478	11	3019.6	102.60
39-479	12	2914.8	101.47
39-484	10	3144.1	102.32
39-489	7	3145.7	102.08
39-522	20	2281.7	101.56
39-523	3	3020.9	104.98
39-527	4	3064.3	102.62
39-530	15	3173.2	102.56
39-531	14	2892.4	103.31
LEM-4	-	-	115.44